Chapter 9

BMP INSPECTION AND MAINTENANCE

Table of Contents

CHAPTER SECTION HEADINGS

FIGURES

TABLES

APPENDICES

1.0. INTRODUCTION

Most of this handbook is devoted to proper design of stormwater management plans, a task that requires a significant investment of effort and expense. Once they are constructed best management practices (BMPs), also known as stormwater control measures (SCMs), are crucial in protecting water quality from the impacts of development projects. However, an essential component of a comprehensive stormwater management program is the ongoing operation and maintenance of the various components of the stormwater drainage, control, and conveyance systems. Failure to provide effective maintenance can reduce the hydraulic capacity and the pollutant removal efficiency of BMPs and conveyance systems. ***BMP maintenance is the purposeful management of a BMP to maintain a desired level of performance and efficiency.***

Typically, we think of structural stormwater BMP operation for optimizing (1) the reduction of runoff volumes/rates via the management of stormwater networks or treatment trains and (2) the removal of pollutants. The site-specific selection of BMPs, their location in the site plan, and their specific design all influence the amount of long-term maintenance that will be required. If designed correctly, BMPs can also be an aesthetic asset to the development. However, no matter how well they are designed and constructed, BMPs will not function correctly nor look attractive unless they are properly maintained. In addition, a lack of BMP maintenance can result in not just missing pollutants which the devices are designed to capture and treat, but generation of additional pollution **(Figures 9.1 and 9.2)**.

Figure 9.1. An unmaintained stormwater conveyance channel now generating sediment to the receiving channel
(Source: CWP, 2009)

We need to think of BMPs as pollution removal devices, just like wastewater treatment plants. As with any infrastructure, deferred maintenance can increase costs and negatively affect receiving waters. Unmaintained BMPs will ultimately fail to perform their design functions and might become a nuisance or pose safety problems. Local governments inherit problems arising from deferred maintenance. Most maintenance problems with BMPs are less costly to correct when they are caught early – as the old adage goes, "an ounce of prevention is worth a pound of cure." Therefore, developing and implementing an effective maintenance program is essential. As well, designers should give considerable thought to future long-term maintenance during the design of site plans and stormwater management practices. The need for on-going maintenance is a fact of life. Most people would never consider spending lots of money to buy a new car and then never change the oil, rotate/align the tires, have the brakes inspected and, as needed, repaired, etc. The same considerations apply to the need to maintain stormwater management BMPs.

Bioretention swale clogged with sediment.


Bioretention area does not drain properly.

Curb inlets to bioretention swale have eroded.


High plant mortality has occurred.

Site runoff bypasses bioretention swale.


Some site runoff bypasses bioretention.

Figure 9.2. Common Issues with Installation of Post-Construction BMPs (Example: Bioretention)
(Source: CWP, 2009)

However, in the world of stormwater management BMPs, that is typically what happens. The field is ripe with studies and stories about the lack of BMP maintenance and quick failure of BMPs (sometimes within as little time as two years). The damage that results is usually difficult to pin down, and so the clean-up is often done at taxpayer expense. In essence, taxpayers are rewarding poor performance by some property owners, and most don't even realize this is happening.

Increasing focus on mass balances, numeric goal setting, emerging effluent limits and total maximum daily loads (TMDLs) now requires that much more emphasis be placed upon BMP operation and maintenance for permitting and reporting requirements – for example, for the municipal separate storm sewer system (MS4) permits, and as a part of stormwater pollution prevention plan (SWPPP) reporting (Kang et al., 2008). With the increasing municipal oversight and the threat of fines from federal, state and local agencies, BMP owners are likely to become more attentive to routine inspection and maintenance of these devices.

This chapter will discuss the logistical issues associated with inspection and maintenance of post-construction stormwater control measures, as well as provide an overview of some of the tasks associated with maintaining BMPs. Three approaches to maintenance are discussed in detail: (1) limited local government responsibility (maintenance done primarily by landowners), (2) expanded local government responsibility (more sharing of responsibility), and (3) and comprehensive local government responsibility. This chapter also discusses BMP design and construction considerations that affect maintenance and provides tips and sample checklists for conducting inspections. In addition, it presents strategies for public involvement in maintaining BMPs.

In addition, each of the BMP design specifications on the Virginia Stormwater BMP Clearinghouse website includes a discussion of the specific inspection and maintenance activities required to ensure the proper functioning of the BMP. As well, **Appendix 9-B** of this chapter includes examples of BMP Maintenance Agreements, and Appendix **9-C** includes examples of inspection-maintenance checklists for each non-proprietary BMP. **Appendix 9-D** provides guidance regarding how to design and construct BMPs to minimize maintenance needs.

9.1. HISTORY OF STORMWATER MANAGEMENT OPERATIONS & MAINTENANCE

During the 1970s and 1980s, stormwater management consisted of "peak shaving" facilities where peak flow under post-development conditions was reduced to that under pre-development conditions (2-year storm control for receiving channel protection, and up to the 100-year storm for flood protection). These facilities did not require sediment removal maintenance, since the residence time of water within a peak shaving facility was on the order of several hours and there was marginal sediment/pollutant accumulation. Peak shaving facilities were designed to require as little maintenance as possible. However, such facilities still require regular inspection and maintenance of inlet/outlet structures and emergency spillways and routine trash removal, etc.

The introduction of stormwater control measures for water quality control has changed operation and maintenance (O&M) needs. Many pollutants such as metals, bacteria, and nutrients bind to sediment. The treatment mechanism for many BMPs includes or is based primarily on filtering or settling sediment, which results in the need to regularly remove accumulated sediment.

Stormwater BMP maintenance is the responsibility of the developer during the construction period. Following construction, stormwater facilities located on private property are typically the responsibility of the property owner or a neighborhood association. As required by the state regulations, the local stormwater management program often requires a formal maintenance agreement, which specifies a required maintenance schedule and gives the local government the right to enter the private property and conduct inspections and maintenance activities. Historically, maintenance activities are difficult to implement for the reasons outlined in **Table 9.1. Appendix 9-A** provides the results of a 2008 field survey of BMP maintenance.

Table 9.1. Common Maintenance Pitfalls

ISSUE	EXPLANATION
Insufficient funding	At the root of many maintenance problems is the lack of a stable, long-term funding source. Depending on the level of service a community provides, performing BMP inspection and maintenance can be expensive. It is a real challenge for many communities to know what resources are needed to fund maintenance and repairs and to develop a system that provides consistent funding over the long term.
Uncertainty of the physical location of BMPs	In many communities, the location of stormwater BMPs and conveyance infrastructure has not been tracked as they are constructed. Typically, many communities are not aware of the total number of practices within their boundaries, or whether the BMPs approved have actually been constructed.
Inability to track responsible parties	Even if a community (or local government) is able to track the location of a BMP, the land ownership often changes hands, and the community might not know who the current owner is at a given time. Another common problem is that a homeowners association (HOA) can change leadership or dissolve over time, leaving no real mechanism to maintain existing BMPs.
Lack of dedicated inspection staff	Inspecting and maintaining stormwater BMPs is potentially a full-time job, but few communities have a full-time inspector on staff. As a result, repairs are often ordered in response to citizen complaints, rather than as a part of a comprehensive maintenance plan. Thus, many of the practices that are “out of sight” (e.g., underground practices) go without needed maintenance, resulting in a significant loss of pollutant-removal capability.
BMP designs that are not conducive to easy maintenance	Many BMPs have been constructed without design features that reduce the maintenance burden over time. Examples include inadequate maintenance access, insufficient pretreatment, inlets and outlets prone to clogging, and designs that require confined space entry for maintenance. Lack of adequate design for maintenance increases the frequency of needed maintenance activities, and it hampers the ease with which maintenance and inspections can be conducted.
Lack of compliance and enforcement authority/access	Although many communities have maintenance requirements incorporated into a stormwater ordinance, many also lack the real teeth to ensure that maintenance actually happens. Important compliance issues include escalating enforcement procedures (as problems become increasingly severe), maintenance access, and legal authority to inspect and to compel maintenance.
BMP owners unaware of maintenance responsibility	As a property changes hands, maintenance agreements and other documents outlining maintenance needs are easily lost or buried within property deeds. This leaves practice owners unaware of long-term BMP maintenance responsibilities and costs.

Source: CWP 2008

9.2. GETTING STARTED: SCOPING OUT THE MAINTENANCE PROGRAM

A great deal of effort is involved early in the process of developing a stormwater management (SWM) program. Getting appropriate BMPs included on design plans and constructed properly in the field is a major accomplishment, but it is only the beginning of the actual life of the BMPs. Local SWM programs in Virginia have a legal mandate in the Virginia Stormwater Management Law and Regulations to require inspection and maintenance of BMPs (§ 62.1-44.15:27 E 2, Code of Virginia, and §§ 4 VAC 50-60-106 A 5 and 4 VAC 50-60-114 of the Regulations). Therefore maintenance duties must not be neglected. In order to assure effective BMP maintenance, the local program must establish proper legal authority to accomplish the following: (1) assigning maintenance responsibility through legally binding agreements; (2) providing adequate access to BMPs; and (3) enforcing compliance with maintenance requirements.

Typically, we think of the operation of a structural stormwater BMP as optimizing (1) the reduction of runoff volumes/rates via the management of stormwater BMP networks or treatment trains, and (2) the removal of pollutants. BMP maintenance is the purposeful management of a BMP to maintain a desired level of performance and efficiency of its operation. Maintenance consists of short-term (routine or more frequent), long-term (non-routine or less frequent), and major (rare) actions, as depicted in **Figure 9.3**.

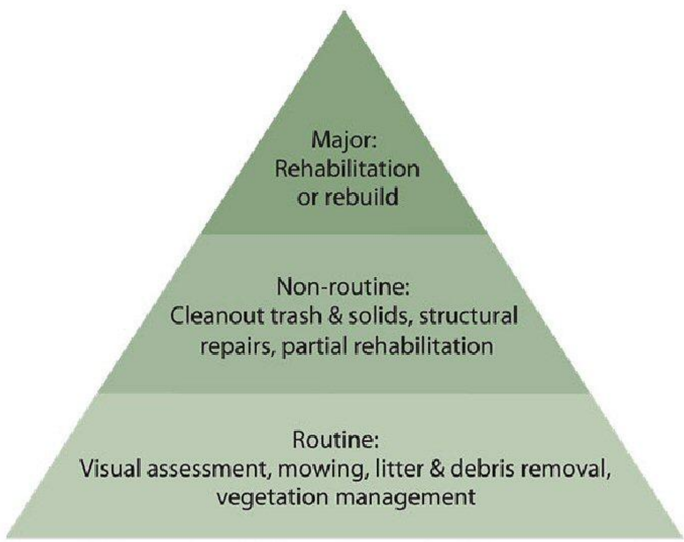


Figure 9.3. BMP Operation & Maintenance Pyramid
Source: *Stormwater*, 2008

Stormwater BMPs have a lifecycle – from their creation (design and construction) through their operative stages (functional or not) – that is largely dictated by operation and maintenance (O&M) actions. Since maintenance involves a significant amount of resources (personnel, equipment, materials, trash/sediment disposal expenses, etc.), the better we understand BMP operation, the more likely we are to maintain optimal performance and improve cost efficiencies (Kang, et al., 2008).

Table 9.2 is a maintenance program service matrix that may help a local program manager scope out the types of maintenance and level of service appropriate for the program.

Table 9.2. Maintenance Program Service Matrix

Program Level of Service	Drainage System Element Included in Maintenance Program	Maintenance Task	Maintenance Response	Inspectors	Inspection Response	Program Feedback Based on Inspections and Maintenance Experience
LOWER	BMPs on public land and within public rights-of-way	Repair immediate threats to public health and safety	React to complaints and emergencies	Rely on owners and HOAs to inspect	Complaint driven	Feedback is anecdotal
⇩	+	+	+			+
⇩	High-priority, high-risk, and/or large BMPs on private land with necessary easements and agreements	Repair structural items: erosion, outfalls, clogged or broken pipes	Establish schedule for mowing and trash/debris removal	Public inspectors send report to responsible party	Every 3 years	Feedback used to modify list of recommended BMPs in design manual based on maintenance burden
⇩	+	+	+			
⇩	All or most BMPs on private land within easements and covered by deeded maintenance agreement	Also include routine maintenance: mowing, weeding, removal of trash and debris, replacement of vegetation	Conduct maintenance in response to inspection reports, checklists, and performance criteria	Co-inspections with public inspector and responsible party	Annual or semi-annual	+
HIGHER	+	+				
⇩	Completely private BMPs			System of certified private inspectors with spot inspections and compliance checks by public agency	More frequent for high-priority BMPs	Feedback used to modify design standards in manual to reduce maintenance burden through initial design
	+					
	All conveyances (pipes, ditches, flood plains)	Program includes system to retrofit or reconstruct BMPs				

System components and maintenance response can increase as programs mature.
The matrix is a tool to set priorities and plan for future program expansions.
(+) means that services are cumulative (level of service includes all previous tasks).

Source: Managing Stormwater in Your Community: A Guide for Building an Effective Post-Construction Program, CWP 2008

The following questions are designed to assist stormwater managers in evaluating their maintenance program responsibilities.

9.2.1. How large is the maintenance task? Developing an Inventory.

It is difficult to develop an effective maintenance program unless an inventory of existing and anticipated future BMPs has been conducted. Without knowledge of the type and locations of stormwater infrastructure components, no comprehensive maintenance plan can be developed.

The following information is necessary in a stormwater management system inventory:
- Facility and conveyance locations;
- Elevations;
- Outfalls;
- Contributing drainage areas;
- Control structures;
- Material types;
- Vegetative species; and
- Any other pertinent information necessary to defining the kind of maintenance required for the facility or conveyance.

An important part of the inventory is assessing the physical and regulatory condition of the system. The physical condition includes the stability and functionality of BMPs and conveyances. The regulatory condition addresses whether BMPs and conveyances are located within easements, have proper maintenance access, and are covered by maintenance agreements or covenants.

This type of information is easily incorporated into a GIS system database. Included in the database can be dates of previous inspections, inspection findings and recommendations, maintenance dates, specific tasks performed, and digital photos of the structure or conveyance. See **Section 9.4.9** for more specific guidance about inventories and tracking systems.

Local programs must also determine what elements of the drainage infrastructure should be included in the maintenance program and who will be responsible for which elements. For example, will the maintenance program be limited to the actual BMPs, or will it also include conveyance systems (pipes and ditches), discharge points, floodplains, and/or stream channels?

9.2.2. Who is responsible for maintenance?

Communities must make decisions concerning the construction, operation and maintenance of the stormwater management infrastructure. For which parts of the stormwater system should the local government be responsible? What services should the local government provide to various parts of a stormwater management system? How do we define exactly what makes up the stormwater management system? And how do we transform our current maintenance policies to a newer definition of responsibility? Deciding who will be responsible for BMP maintenance is an important policy decision, and there are multiple options. This decision may depend on the status of easements, maintenance agreements, and whether maintenance tasks are aesthetic or structural.

There are two types of maintenance: structural and routine. Structural maintenance consists of repairing plumbing, components, and infrastructure; it is typically costly and requires an enhanced level of expertise. Routine maintenance involves removing accumulated trash and debris and managing vegetative growth (see **Table 9.3**).

Table 9.3. Examples of Structural Routine Maintenance

Structural Maintenance items	Routine Maintenance Items
▸ Clogged or broken Pipes ▸ Missing or broken parts (e.g., valves, seals, manholes) ▸ Cracked concrete ▸ Erosion at outfall or on banks ▸ Sinkhole formation or subsidence within the practice's footprint ▸ Regrading or dredging ▸ Landscaping needs complete refurbishment	▸ Mowing ▸ Removal of small amounts of sediment ▸ Removal of vegetative overgrowth and woody plants ▸ Removal or trash and yard debris ▸ Replacing dead or diseased landscaping ▸ Control of invasive plants

Source: CWP 2008

Unmaintained stormwater facilities will eventually fail operationally. A major contributor to unmaintained facilities is a lack of clear ownership and responsibility. In order for an inspection and maintenance program to be effective, the roles for each responsibility must be clearly defined prior to construction of a system. The lead role in determining what responsibilities belong to whom lies with the local government. Several different approaches are possible and are briefly described below. A community must determine which approach best suits its capabilities, both physically and financially. **Table 9.4** below outlines the characteristics of each approach, as well as typical program budgets and funding mechanisms. Most stormwater programs include features from all three approaches (No. 4, the hybrid approach).

9.2.2.1. Limited local government responsibility

Traditionally, maintenance is the responsibility of the property owner, which in most cases is a private individual, corporation, or homeowners association. However, some communities assume partial or complete responsibility for BMP maintenance. The narrowest approach for communities to take in defining responsibilities for stormwater systems would be for the local government to accept responsibility only for property owned by the community. This would include the right-of-way and any other publicly owned land such as local facilities and parks. With this approach, the community would not be involved with any stormwater systems on private property, except for possible regulatory action. Simple maintenance items such as minor landscaping tasks, litter removal, and mowing can be done by the owner, or can be incorporated in conventional grounds maintenance contracts for the overall property.

Table 9.4. Three Maintenance Program Approaches

Typical Program Characteristics	Typical Annual Maintenance Program Budget Range*	Typical Funding Mechanisms
1. Limited Local Government Responsibility		
• Local government maintains facilities on public land and/or major private facilities within easements, while private parties are responsible for facilities on private property • Most common maintenance approach • Can be cost-effective, but still requires local government budget and staffing	\$50K to \$300K	Stormwater Utility Capital improvement program General Fund
2. Expanded Local Government Responsibility		
• Local program responsible for more maintenance functions (typically adding the potentially most troublesome at at-risk systems to publicly owned systems)	\$100K to \$500K	Any of the above plus Stormwater Utility fees
3. Comprehensive Local Government Responsibility		
• Local program responsible for most maintenance functions • Owners may be responsible for routine tasks (mowing, picking up trash, weeding, aesthetics) • Requires highest budget and staff commitment • More common in cities and towns with an established public works function and jurisdiction over roads and drainage	\$100K to \$1.5M	Stormwater Utility Other utility (e.g., sewer rates, etc.) Transportation maintenance funds General Fund
* Maintenance program budget figures were derived from research on local stormwater programs, primarily Phase II MS4s, conducted in 2005 (**CWP, 2006**). Because most programs are still in the early stages of program development, these figures represent nominal costs associated with a maintenance program, and do not include other costs, such as the cost of stormwater capital improvement projects. Costs will increase as program responsibilities and accountability increase. Typically, larger municipalities, such as Phase I communities, have much larger maintenance budgets.		

Source: Adapted from CWP 2008

Placing maintenance responsibility in the hands of individual property owners, Homeowner Associations (HOAs) and business owners significantly reduces the costs to the municipality and may be the best option for small communities that cannot afford to allocate staff and crews to maintain BMPs. The local program still must has a significant role under this option however, by educating property owners and HOAs, conducting periodic inspections, tracking maintenance, and initiating enforcement when needed. This approach necessitates that property owners are aware of and routinely budget for the ultimate time and costs of maintenance activities. If the local program fails to fulfill its education and oversight roles, an inadequate level of maintenance is inevitable.

Responsible parties can conduct inspections with in-house personnel (or properly trained HOA volunteers) or by hiring a contractor. This approach still requires the local program staff to conduct spot inspections and to ensure overall compliance. Using this approach, private landowners or HOAs are primarily responsible for routine maintenance and major structural repairs. Public maintenance, where it does occur, is typically limited to facilities on public property.

While this approach may seem most easily defined, there are some drawbacks. Parties who have little knowledge or funding to maintain stormwater systems, own many of the stormwater system components that are on private land. For example, many residential subdivisions contain a stormwater pond, frequently located on one of the less desirable lots. The homeowners association is typically the owner of such a pond. These groups generally have little understanding of the purpose of the pond and how it operates, and have even less funding available to repair and maintain it. The stormwater pond will typically fall into disrepair and become overgrown with vegetation and lose any viable functionality. Even worse, if left in disrepair for a long enough time, the disrepair may result in a dam failure. Many light commercial stormwater systems also fall into this same state for the same reasons.

If a locality decides to use the approach of limited local government responsibility, the jurisdiction will have to put forth some effort to prevent these drawbacks from occurring. It may be possible for the community to make this approach work with a proactive inspection program to review private systems, and a strong public education program to insure that owners understand their responsibility and perform their required duties. Private owners should also be made aware of the need to plan how they will fund their maintenance programs. For the residential example above, dues to the homeowners association could be earmarked for maintenance and set at a level that will assure that enough funds will be available for potentially expensive dredging or repairs.

9.2.2.2. Expanded local government responsibility

In addition to maintaining and operating publicly owned stormwater systems, the community may determine that it should maintain and operate some of the private portions of the system. This approach could be chosen in an attempt to eliminate the problems mentioned above.

The difficulty with expanding the responsibility of the local government is in determining where to end local responsibility and how to fund the extra responsibilities. These decisions must be made in a fair and equitable manner. One option for this approach would be for the community to accept operation and maintenance responsibilities for all residential stormwater systems, but not for any commercial or industrial systems.

9.2.2.3. Comprehensive local government responsibility

The opposite of a limited approach would be a comprehensive approach, where the community conducts all operation and maintenance activities for stormwater systems within its jurisdictional boundaries. This type of approach may be deemed to be the best approach if the community has serious nonpoint source pollution issues, especially if there is a possibility of regulatory action by the federal or state government. This type of approach would also be well suited to the community that has a stormwater utility in place and/or operates and maintains regional stormwater management systems instead of a myriad of small on-site systems. Because of the inherent problems associated with private maintenance responsibilities, the most efficient organizational structure would be to give the jurisdiction ownership or easement access to the stormwater system. This would place the responsibility for the overall stormwater system with one entity. A comprehensive and cohesive program could be developed and implemented by the jurisdiction for inspection and maintenance.

This approach is not widespread among communities, primarily because of the high costs, extensive staffing requirements, and administrative burden placed on the program. This approach, however, has some advantages. Time-consuming public education and enforcement issues can be avoided, and the local program has more control over when and how maintenance is accomplished. In many cases, municipalities can transition from private maintenance (Approach 1) to local program maintenance (Approach 3) as the program matures. This transition would require the local program to inventory existing BMPs and conveyance systems to determine the immediate maintenance needs.

This option requires the most time, staff, and funding, but it provides local programs with the best control over inspections. An alternative is for the local program to *hire contractors to conduct inspections*. Doing that reduces staff time, but it requires contract management and quality control to ensure that thorough inspections are conducted. Furthermore, local program staff members would still be responsible for compliance and enforcement. In general, the comprehensive approach requires local programs to collect and manage detailed information about each BMP, maintain a team of dedicated staff, and secure funding.

The most difficult aspect of this approach may be how it would be funded. The most logical option for funding would be to adopt a local stormwater utility fee based on the amount of stormwater and pollution contributed by each site.

9.2.2.4. Be Clear about Various Maintenance Responsibilities

Respective maintenance responsibilities must be clearly outlined to achieve program success. One danger of a hybrid system is that maintenance responsibilities may not be systematically assigned and communicated. Local program staff must understand who is responsible for which maintenance tasks and must ensure that private parties understand their roles. The following is a list of methods that can be used to communicate and clarify roles and responsibilities:

Table 9.3 (above) lists tasks necessary to maintain the drainage system, which could be assigned to the local program or private parties for maintenance. Assuming that most or all of the functions in **Table 9.3** must be performed by some party, the following activities may help the local program to delegate responsibilities:

- Make explicit policy decisions based on program goals and the characteristics of the community. Don’t assume that all parties will know what they’re supposed to do.
- Use a deed of easement or easement agreement to clearly outline rights and responsibilities. See also **Table 9.8** (Considerations for Stormwater Easements).
- Use a maintenance agreement that clearly outlines responsibilities for routine versus structural maintenance.
- Develop a guidebook or other outreach materials geared toward HOAs and responsible parties.
- Explain maintenance responsibilities during co-inspections.
- Include maintenance information on the local program web site.

- Local program staff should monitor all private-party activities to ensure that appropriate inspection and maintenance tasks are performed.

Of the above given approaches to local responsibility, each community must determine the amount of responsibility and effort it is willing to commit in order to provide adequate stormwater management. A local government could choose one of the approaches described above, or could choose some point between. Whichever approach is chosen, the decision must be carefully considered and open for change with time and experience. A stormwater management system should have ownership and maintenance responsibilities clearly defined from the initial stages of design. It should be clear and unequivocal what entity has responsibility for each portion of the system.

9.2.3. Maintenance inspections

An effective inspection program is necessary to ensure a stormwater facility or conveyance remains operational. Inspections should be performed on a regular basis and scheduled based on the type and characteristics of the stormwater control measure. In addition, inspections should occur after major rainfall events for those components deemed to be critically affected by the resulting runoff. Not all inspections can be conducted by direct human observation. For subsurface systems video equipment may be required. There may be cases where other specialized equipment is necessary. The inspection program is tailored to address the operational characteristics of the system.

It is not mandatory that all inspectors be trained engineers, but they should have some knowledge or experience with stormwater systems. Trained stormwater engineers should, however, direct them. Inspections by registered engineers should be performed where routine inspection has revealed a question of structural or hydraulic integrity affecting public safety.

The inspection process should document observations made in the field. Comments should be archived on structural conditions, hydraulic operational conditions, evidence of vandalism, condition of vegetation, occurrence of obstructions, unsafe conditions, and build-up of trash, sediments and pollutants. This is also an efficient way to take water quality measurements required for monitoring programs and to incorporate them into the inspection history. The inspection data should be ideally incorporated into a GIS database, if possible, as it allows spatial identification of where maintenance activities are required or have occurred. Trends may be identified in this way that can assist a community in tracking down specific system components that cause chronic problems.

9.2.4. What "level of service" is desired for the maintenance program?

The level of service defines the frequency and scope of maintenance and the kinds of activities that receive oversight through the maintenance program (see **Table 9.2**). The regulations address this to some degree, but each individual maintenance agreement must specify a schedule of maintenance activities. Schedules will vary somewhat, depending on the size and type of BMP and the associated risks if maintenance does not occur.

In addition to determining the extent of responsibility that a community is willing to assume, a decision must be made about how the stormwater system will serve the community. This decision determines the *level of service* (LOS) that the system must achieve. The level of service is defined two ways: (1) performance level of service and (2) maintenance level of service.

The susceptibility of a community to flooding or water quality problems due to stormwater can be measured by assessing the performance level of service available. For example, for flooding issues, a level of service can be expressed in terms of the degree of roadway flooding and/or the extent of first floor flooding for a given hypothetical storm event. For some communities, a level of roadway service may be defined as having no less than one open lane on evacuation routes during the largest one-day rain event with a 25-year recurrence interval. LOS definitions vary considerably by community and are defined as a design frequency tied to a specified condition (e.g. the 10-year storm design frequency for culvert overtopping). Compared to a flooding LOS, the concept of a water quality level of service is fairly new. A water quality LOS system might promote land use controls, followed by structural treatment measures, and may penalize untreated discharge from urban areas.

A maintenance level of service is defined by the types of services a community will provide to different parts of the drainage system or by the specific condition of the system. For example, within the right-of-way and in critical areas highly susceptible to flood damages, the maintenance level of service might include periodic inspection, priority cleaning and the highest level of emergency response. In similar right-of-way areas not susceptible to flooding, the level of service for maintenance might be much lower. A community might perform maintenance for residential structural stormwater controls, but only provide inspection and enforcement of maintenance agreements for structural controls located on non-residential parcels.

Maintenance levels of service can also be defined in terms of the condition of the system. Channel mowing may take place when the grass is about 8” high. Or culverts might be cleaned out when they are, on average, 20% blocked with sediment. In these cases inspection of the systems drives work orders rather than flooding complaints.

The extent or responsibility and level of service combine to define the capital project (construction or land acquisition) and operation and maintenance programs. For example, it might be that on private land a local government is only willing, and only has the resources, to perform emergency response services and to give technical advice. But in the high priority public rights-of-way, the local government may be willing to provide a much higher level of service. If a community chooses a low-level stormwater maintenance program with minimal responsibilities, it should anticipate increasing complaints and an unknown but growing backlog of unmet capital construction and remedial maintenance needs. No stormwater management system can function for long without adequate attention. Maintenance avoided is simply maintenance deferred.

9.2.5. Establishing maintenance responsibility and level of service policies

A drainage system, starting from the headwaters and moving downstream toward the mouth, carries incrementally larger and larger flows. The *extent of responsibility* policy seeks to define the dividing point in this dendritic system between local government and private responsibility. The basic components and limits of that responsibility are also defined in extent of service.

The extent of responsibility will almost certainly change over time, both in terms of the local government's policies and the application of those policies. For example, in terms of routine maintenance of the systems, the extent of responsibility may consistently be limited to those components within rights-of-way and easements which allow adequate access to the facilities, but rights-of-way and easements will be added over the years, so the practical extent of responsibility will expand even if the policy does not change.

The extent of responsibility for regulatory activities must go far beyond the rights-of-way and easements to meet the local government's stormwater quantity and quality control responsibilities. Often the community must determine its regulatory extent of responsibility (through its authority for land use control) based on what must, or can, be done on private property in order to protect the general public health, safety, and welfare.

How far into the system should a local government provide service? All of the drainage system can be categorized according to location, conveyance and legal standing:
- In or outside the public right-of-way;
- Does, or does not contain significant public water; and
- Is or is not within a permanent dedicated drainage easement.

Thus, there are typically four “policy” categories of drainage system:
1. Within the right-of-way;
2. Outside the right-of-way, carrying public water and within an easement;
3. Outside the right-of-way, carrying public water but not within an easement; and
4. Totally private systems.

Based on its definition of the system components, the community can determine how it will handle the various portions of the drainage system. Generally:
- The minimal extent of responsibility is within the public right-of-way. Every local government has a public health and safety responsibility to keep its travelways open to traffic and free from dangerous amounts of standing water.
- Often communities also provide maintenance service, of some sort, within permanent drainage easements. This is especially the case when there is both public water and a public interest in keeping a certain drainageway functional.
- Some also have established the policy that they will provide some service to other parts of the drainage system that carry public water (i.e. downstream from the first public street). In other locations, only an inspection and enforcement service is provided outside the right-of-way and easements.
- Most communities will respond to any location whatsoever in an emergency situation.

When developing changes to a maintenance program it is helpful to remember these three basic steps:

1. Define the Program
    - Determine segment category definitions
    - Determine level-of-service and policy definitions
    - Determine resource demands and available budget
    - Develop policies for each segment category

2. Define the System

- Inventory and map the stormwater management system
- Identify the “official” system (right-of-way and key segments outside ROWs)
- Assign segments to the system

3. Initiate Changes

- Begin changes in service
- Expand slowly as experience is gained

9.2.6. Should the local program use in-house resources, a contractor, or both to perform maintenance tasks?

Local program managers who operate large, public facilities may use in-house staff to conduct BMP maintenance in conjunction with operating and managing utilities, buildings, and roads. For many smaller programs, however, employing private contractors is more efficient than hiring new staff and purchasing equipment. Another option is entering into an agreement with a water and sewer utility, Soil and Water Conservation District, neighboring jurisdiction, or transportation agency to share maintenance responsibilities and maximize economies of scale in the use of equipment and personnel. The increased emphasis on stormwater facility maintenance is stimulating the development of new companies focusing on this niche business opportunity to provide such maintenance services (similar to the companies that now provide erosion and sediment control facility installation and maintenance services).

Although non-professionals can undertake many maintenance tasks effectively, a professional should be consulted periodically to ensure that all needs of the BMP facility are met. Elements where the professional judgment of a professional engineer may be needed include structures, outlets, and embankments/dams. As well, the health of vegetation associated with BMPs may require the attention of an appropriate plant professional. Some developing problems may not be obvious to the untrained eye.

In addition, it is advisable to have professionals do the more difficult or specialized work. Filling eroded areas and soil-disturbing activities, such as re-sodding or replanting vegetation, are tasks that are best assigned to a professional landscaping firm. If the work is not done properly the first time, not only will the effort have been wasted, but also the facility may have been damaged by excessive erosion. Grading and sediment removal are best left to professional contractors. Appropriate professionals (e.g. BMP maintenance specialists, professional engineers, aquatic plant specialists, etc.) should be hired for specialized tasks such as inspections of vegetation and structures.

9.2.7. Maintenance scheduling and performance

Maintenance activities can be divided into two types: scheduled and corrective. Scheduled maintenance tasks are those that are typically accomplished on a regular basis and can generally be scheduled without referencing inspection reports. These items consist of such things as vegetation maintenance (such as grass mowing) and trash and debris removal. These tasks are required at well-defined time intervals and can be considered a routine necessity for most, if not all, stormwater structural facilities. A permanent maintenance crew is typically put under a fixed scope of responsibility to address these items.

Corrective tasks consist of items such as sediment removal, stream bank stabilization, and outlet structure repairs that are done on an as-needed basis. These tasks are typically scheduled based on inspection results or in response to complaints. Corrective maintenance sometimes calls for more specialized expertise and equipment than for scheduled tasks. For example, a task such as sediment removal from a stormwater pond requires specialized equipment for which not every jurisdiction is willing to invest. Therefore, as noted above, some maintenance tasks might be effectively handled on a contract basis with an outside entity specializing in that field. In addition, some corrective maintenance may also require a formal design and bid process to accomplish the work.

9.2.8. How will maintenance compliance be tracked, verified, and enforced?

Local stormwater ordinances and program tracking and evaluation systems are key components of a strong program. Certain stormwater plans must have a recorded Maintenance Agreement before the plan is approved. There must also be some type of compliance mechanism to assure that maintenance is actually performed on a regular or as-required basis.

One method for ensuring maintenance is the implementation of a stormwater system operating permit and/or maintenance agreements. This kind of approach would produce information for inclusion in a stormwater inventory database, thus adding to the efficiency of a local maintenance program, as well as providing a funding mechanism through permit fees. Some key aspects of these permits or maintenance agreements is the clear delineation of responsibilities, such as the following:

- Identification of who will perform inspection duties and how often.
- Listed duties that are to be performed by the owner, such as mowing, debris removal, and replanting of vegetation.
- Defined roles for the local government, possibly inspection, and/or modifications to the system such as resizing an orifice.
- Determination of a recourse of action to be taken if the owner does not fulfill their obligations (i.e. repayment to the local government for activities that the owner did not perform).
- Development of a pollution prevention plan by the owner.
- Requirement of a report, possibly annually, that would serve to keep the owner involved and aware of their responsibilities.

For example, a permit or maintenance agreement could specify that the local government accepts responsibility for inspecting and maintaining the stormwater system's structural components, including the periodic removal of debris and accumulated sediments, but that vegetative and aesthetic maintenance would still rest with the private entity.

These Maintenance Agreements can be used to help track maintenance. Checklists based on the Maintenance Agreement can then be used to determine whether performance criteria have been met. Inspection/Maintenance checklists for each of Virginia's approved non-proprietary BMPs are included in **Appendix 9-C** at the end of this chapter. Each checklist, at a minimum, should include the following:

- Date of the inspection and name of the inspector.
- Identification and location of the BMP being inspected
- Condition of each of the BMP components.
- Any maintenance work that was performed (as well as who performed the work).
- Any issues noted for future maintenance (sediment accumulating, vegetation needing pruning or replacement, etc.).

All inspection and maintenance activities should be recorded. Each project should have a maintenance record. Any deficient BMP components noted in the inspection should be corrected, repaired or replaced immediately. These deficiencies can affect the integrity of structures, the pollutant removal efficiency of the BMP, and public safety. Major repairs or maintenance work should include the same level of inspection and documentation as for the original installation. Inspection checklists and record logs should be kept in a known set location. When necessary maintenance is not performed, mechanisms must be in place to enforce compliance.

It is advisable to prepare an annual maintenance report to document maintenance activities. In fact, annual maintenance reports are typically necessary for MS4 programs, since consistent BMP maintenance is a permit condition. Annual reports provide the local program an opportunity to identify important maintenance issues that may need to be checked on during the subsequent year. Ideally, the annual report should provide the following information:

- Observations resulting from inspections:
  - Hydraulic operation of the facility (detention time, evidence or occurrence of overflows);
  - Condition of vegetation in and around the facility;
  - Occurrence of obstructions at the inlet and outlet;
  - Evidence of spills and oil/grease contamination; and
  - Frequency of trash build-up.
- Measured sediment depths (where appropriate);
- Monitoring results, if flow or quality monitoring was undertaken;
- Maintenance activities performed;
- Maintenance activities needed in the coming year; and
- General recommendations for the inspection and maintenance program for the coming year.

9.3. ESTABLISHING AN EFFECTIVE MAINTENANCE PROGRAM

Regardless of who has responsibility for specific program elements, the following are issues and tasks that must be addressed in order to establish an effective local BMP maintenance program.

9.3.1. Develop Program Documents

The program's legal and administrative foundation must be established in the local stormwater management ordinance, design or policy manual, and other forms and applications used to implement the program. A preliminary list of necessary documents is provided in **Table 9.5**.

Table 9.5. Legal and Administrative Foundation for a Maintenance Program

Stormwater Ordinance	Design/Policy Manual	Other Forms and Applications
Requirement for responsible party to maintain BMPs		Maintenance Handbook or guide for responsible parties
Reference to general design standards that include features that reduce maintenance	Detailed maintenance reduction design specifications (on Virginia Stormwater BMP Clearinghouse web site)	
Requirement for a maintenance agreement or covenant recorded with property deed	Standard (template) maintenance agreement(s) (in Appendix 9-B of this chapter)	
Requirement for easements	Standard easement deed and specifications (when required, width, rights of grantor and grantee)	
Maintenance inspection frequency and reporting	Inspection/Maintenance checklists and sample operation and maintenance (O&M) plans (in Appendix 9-C of this chapter)	
Requirement for performance bond to cover initial installation and period of operation (e.g., 2 years)	Performance bond forms	
Compliance and enforcement tools, including injunctions, consent orders, civil penalties, fines, or jail, depending upon the nature of the violation (potential misdemeanor or felony charges); ref § 62.1-44.15:48, Code of Virginia)	Notice of Violation letter template Schedule of civil and/or criminal penalties	Civil penalty "ticket book" for inspectors

Source: Adapted from CWP 2008

9.3.2. Establish Maintenance Policies and Funding

This step requires critical policy-making decisions, which serve as the foundation for program budget and staffing and for determining the appropriate level of service. A typical decision may include determining who will be responsible for structural versus routine maintenance (see **Table 9.3** above). See **Table 9.2** above for additional level-of-service policy decisions.

In most communities, simple aesthetic and routine tasks, such as mowing and trash removal, are performed by the property owner or responsible party. These activities require equipment and staffing, and they are more challenging for municipalities to undertake on a frequent or routine basis. Assuming the responsibility for such tasks will increase the need for local program staff and additional funding. No matter which maintenance approach is adopted, a reliable source of funding will have to be established to pay for inspection and maintenance expenses.

The expenses associated with maintaining a BMP are highly dependent on the BMP type and its design. However, the most important factor that determines the cost of BMP maintenance is the condition of the drainage area upstream of the BMP. If a drainage area conveys a high load of sediment and other pollutants to a BMP, the cost of maintaining the BMP will increase dramatically. Preventing or minimizing pollution in the drainage area will reduce the cost of BMP maintenance.

If a private landowner or HOA is responsible for some or all BMP maintenance on their property, the owner should establish a funding or savings mechanism should be established and funded regularly with an amount that provides enough money to pay for these maintenance expenses over the lifetime of the BMP. One option is to establish an escrow account, which can be spent solely for sediment removal, vegetative replacement, structural repair, or reconstruction of the BMP(s). In the case of a residential subdivision, the escrow account could be funded by a combination of an initial payment by the developer and subsequent regular contributions by the HOA. For an example of how to legally structure such an account, see the Phase II model stormwater ordinance at the North Carolina DENR-Division of Water Quality's web site, at:

http://h2o.enr.state.nc.us/su/phase_2_mod_ord.htm

Routine maintenance costs are relatively easy to estimate, and include expenses associated with the following activities:

- Conducting BMP inspections at prescribed intervals.
- Maintaining site safety, including any perimeter fencing and other access inhibitors (trash racks or pipe grates).
- Removing trash.
- Removing sediment that has accumulated in any components of the BMP.
- For infiltration systems, maintaining the filtering media and cleaning or replacing it when necessary.
- Restoring soils to assure performance.
- Pruning woody vegetation.
- Replacing dead vegetation.
- Stabilizing eroded side slopes.
- Repairing damaged or eroded outlet devices and conveyance systems.
- Repairing embankments, dams, and channels due to erosion or rodent damage.

Emergency maintenance costs are more difficult to estimate. They depend on the frequency of occurrence and the nature of the problem, which could vary from storm erosion repairs to the complete failure of a structure.

An inventory of BMPs (discussed below) located within the local program jurisdiction is useful in determining the amount of funding that will be needed to implement local BMP inspection and maintenance activities. More and more local governments are considering establishing Stormwater Utilities to generate funding to support administration of their local programs, including long-term inspection and maintenance functions. Stormwater Utilities function in the same way as public utilities responsible for water supply, wastewater treatment, transportation, etc., levying *user fees* to cover the services provided.

9.3.3. Develop Outreach Materials and Programs for Design Consultants, Inspectors and Responsible Parties

One of the most important ways to assure the regular inspection and maintenance of the stormwater infrastructure is through education programs (see **Table 9.6**) for both private owners and the general public. The public can be helpful or detrimental to the success of the community's stormwater management program. Often, property owners are unaware of what a BMP is, how it functions, what is required for maintenance, and how much that will cost.

Table 9.6. Key Stakeholders in Stormwater Maintenance and Selected Strategies

Stakeholder Group	Selected Public Involvement Strategies
Primary Stakeholders	
• Private responsible party or HOA • Public agency inspectors • Public agency maintenance crews	• Co-inspections with responsible party and public inspector • Brochures and mailings to responsible parties • Workshops, certifications, plaques, and other forms of recognition for responsible parties • Adopt-A-BMP programs with training and certification • Workshops for inspectors with field component • Workshops, certification, and recognition for maintenance crews
Other Stakeholders	
• Private sector contractors performing inspections for responsible parties • Private sector contractors performing maintenance tasks for responsible parties • Elected officials • Residents of neighborhoods with BMPs	• Training and certification programs • Periodic updates for elected officials to tout benefits of maintenance program (e.g., cost savings through proactive maintenance) • Hotline for maintenance questions and concerns from the public • General information brochures or Web sites on “what to expect from your neighborhood BMP” • Fact sheet on BMPs, mosquitoes, and West Nile virus

Source: CWP 2008

A good example of the need for public education is residents who use the ditch behind their house to dispose of grass clippings and vegetative debris. This debris can then block a pipe inlet and cause flooding, or cover an infiltration trench and cause excessive runoff. Another common problem is individuals disposing of materials by discharging them into the stormwater drop inlets and catch basins Citizens need to be informed that sediment, vegetative material and harmful substances such as waste oil should not be dumped into catch basins but must be disposed of properly. In many cases, once the public is informed of the purpose of the system, the need to properly maintain the system, and the potential consequences of misusing and not caring for the system, they are less likely to perform acts that inhibit the system or cause adverse impacts.

An additional benefit of an educated public is the opportunity to have many more "inspectors" (eyes on the ground) who will alert system operators of potential problems prior to catastrophic failure. As part of an effective education component, the public should be informed of signs to be aware of that may indicate serious problems. If a citizen is told that the dry detention pond behind his house should not have standing water at all times or should not fill to the top of the dam after every rain event, he or she would then know to alert the proper authorities and could prevent possible damage to life or property.

In addition to public education for publicly owned or operated systems, education can be very important for privately owned systems. Once stormwater structural controls are installed, the end-user or owner may not be aware of the necessity of the facilities or the consequences of a failed system. As part of the public education, it is vital that private owners be educated to understand and become proactive in the operation and maintenance of their facilities. It is in the best interest of the public to make the owners of private stormwater systems aware of the responsibility that goes with ownership and the effect that failure could have on public health and safety.

When development is proposed for a new site, the following educational outreach efforts should be conducted:

- *During Plan Development*: A municipal staff person should be available to the developer, contractor, or design consultant to assist with development of a maintenance plan for each BMP. At the pre-construction meeting, the parties should review the maintenance plan, maintenance responsibilities, and schedules.
- *During Ongoing Maintenance*: The local government is typically the source of technical assistance to HOAs and businesses after the plan is developed. Technical assistance may include providing lists of local contractors who conduct maintenance or repairs, providing advice regarding a budget for maintenance, providing maintenance handbooks written for citizens, and accompanying owners or contractors during routine and post-repair inspections.

Some related programs (e.g., “Adopt-A-Pond”, etc.) develop citizen-friendly guides, training opportunities, and recognition and awards for participants. In addition to providing educational material, some communities have begun inviting or even requiring homeowners to attend workshops to learn about their buffers, rain gardens and other LID-type practices, to create a long-term connection to the local program and convince them that their efforts benefit everyone (Stormwater, May 2008).

Communities can establish a volunteer program for BMP maintenance by recruiting motivated individuals, service groups, neighborhood associations, and school groups. This approach works well for highly visible BMPs that have safe and easy access. Typically, volunteers perform simple inspections and light maintenance tasks such as trash pickup and weed removal. The

volunteers also report serious problems or more labor-intensive maintenance needs to the local program manager. Certificates of accomplishment, prizes, publicity, or other incentives can be used to recruit volunteers and provide a rewarding experience. Several communities sponsor Adopt-A-Pond programs to provide citizens and responsible parties with guidance and resources for maintaining and improving stormwater ponds. An example of such a program from Hillsborough, Florida, can be found at: http://www.hillsborough.wateratlas.usf.edu
The Adopt-A-Pond program could be broadened to include other types of stormwater BMPs.

9.3.4. Verify Maintenance Provisions during Stormwater Plan Review

The plan review process should ensure that all necessary documents are in place when a project is approved. These include the following:

- Maintenance agreements, including the identity of a responsible party and the applicable parcel(s), which are recorded in the property deed;
- Operation and maintenance (O&M) plans and schedules, which are part of the approved plan and/or maintenance agreement;
- Easements, as needed, which are accurate and shown on the final property plat; and
- Performance bonds, if applicable (see § 62.1-44.15:34, Code of Virginia).

BMP facilities are typically built, owned and maintained by non-governmental entities. To insure proper long-term maintenance, the Virginia Stormwater Management Regulations require that a Maintenance Agreement must accompany the design plans for BMPs (4 VAC 50-60-124 provides some discretion regarding BMPs on small lots). A Maintenance Agreement should include the following:

- The frequency of inspections that are needed (based on the type of BMP proposed).
- The components of the BMP that need to be inspected.
- The types of problems that may be observed with each BMP component.
- The appropriate remedy for any problems that may occur.

The most effective Maintenance Agreement is site-specific for the particular BMPs that are used on the site as well as any conditions that are unique to the site (e.g., the presence of steep slopes that should be inspected for soil stability) and includes a schedule of inspection frequency. Sample Maintenance Agreements are included in **Appendix 9-B** at the end of this chapter.

The Maintenance Agreement should be recorded (i.e., filed with the appropriate Register of Deeds). The responsible party should keep a copy of the Inspection and Maintenance Agreement along with a current set of BMP plans at a known set location.

9.3.5. Secure Easements for New BMPs during Plan Review

BMPs must have access and maintenance easements to provide the legal authority for legal access to the site for inspections, maintenance personnel and equipment. The location and configuration of easements must be established during the design phase and should be clearly shown on the design drawings. The access and maintenance easement must include the entire footprint of the BMP system plus at least an additional 10 feet around the BMP, to provide enough room to complete maintenance tasks. The BMP system includes the side slopes, forebay, riser structure, BMP device, and basin outlet structure, dam embankment, and emergency spillway.

Access and maintenance easements must be configured to allow for the maintenance tasks that may be needed. If heavy equipment will be necessary to perform maintenance tasks (such as removing sediment from a forebay), typically a roadway with a minimum width of 12 feet should be provided to the BMP. Easements are usually owned and maintained by the owner of the BMP facility, whether an individual, a corporation, or a unit of government. Easements for BMPs that are not publicly maintained should include provisions to permit public inspection and maintenance. Examples of Maintenance Agreements are provided in **Appendix 9-C** at the end of this chapter, including provisions for access and easements.

Easements may be necessary to assure that important components of the stormwater management plan remain in place over time. This is especially true for site planning techniques that provide runoff reduction benefits (e.g., conserving open space, restoring forest cover, etc.) and LID-type practices that may not be obvious BMPs to property owners (e.g., bioretention facilities that often appear to be merely discretionary landscaping). Securing easements after a project is built and after properties are occupied is time-consuming and uncertain. Therefore, program managers should strive to secure easements during the review of stormwater plans. This requires the stormwater reviewer to coordinate with the department or staff person that reviews property plats for the locality. To have legal standing, the easement must be shown on the plat of record.

Programs that promote low-impact development (LID) types of BMPs and dispersed and distributed runoff reduction practices – possibly on individual lots – may have to develop LID-specific easement policies and procedures. There are legal, administrative, and logistical considerations for having easements cover these types of practices, and for the long-term access and maintenance of the practices. The local program may want to consider a "hybrid" approach (see below) for certain categories of BMPs. The following are some considerations for securing stormwater easements:

- Easements should cover:
  - The BMPs.
  - Enough land around the BMPs for construction equipment to enter and maneuver. This includes access to dams, risers, safety benches, forebays, and outlets, as appropriate.
  - For ponds, a setback (e.g., 25 feet) from the flood (100-year) pool area.
  - Access routes for maintenance.
  - According to program policies, conveyances and structures associated with the BMPs.
- For drainage easements, the easement width should increase as the top width of the channel or depth of the pipe increases. For example, the easement width should be progressively increased in increments of 5 feet for pipes at depths of 10, 15, 20 feet, etc.
- Ensure that access routes are of adequate width (minimum of 12 feet) and an acceptable longitudinal slope (no steeper than 15%). Surfacing should be based on the anticipated frequency of use and types of equipment involved. Although gravel may be a suitable

surface, consider pervious surfaces (e.g., reinforced turf or paver blocks) that do not increase the site's impervious cover.

- Make sure easements are recorded on the property plats and in the deeds.
- An easement agreements or deed of easement will help specify the rights and responsibilities of both the easement holder and the owner. For instance, the deed or agreement can spell out that the owner is responsible for mowing and routine maintenance and that fences and other obstructions are not permitted.

9.3.6. Secure Easements and Agreements for Existing BMPs

Depending on the level of service, securing agreements to access and maintain previously installed BMPs may be necessary. Many existing BMPs require costly repairs to restore effective function. It is not uncommon for the local program to assume responsibility for the BMPs only after the private party (1) conducts maintenance of the BMP to a minimum specified performance level and (2) provides legal access and easement documents.

This aspect of the program can be very time-consuming. It requires documenting the condition of BMPs, negotiating with multiple property owners, and involving legal staff and often elected officials. For these reasons, securing easements and agreements for existing BMPs will likely be a phased program. A scoring or ranking system can help a locality set priorities for this task.

9.3.7. Develop Inspection Procedures

Regular inspection and maintenance is an on-going legal requirement after any BMP is constructed, including pre-treatment devices. Regardless of who is ultimately responsible, it will be important for the local program to have consistent inspection policies, procedures and "tools" to guide the inspection process.

Table 9.7 provides recommendations for the frequency of inspections, depending upon the type of BMP involved. Ideally, at least during the first two years of operation, devices that include vegetation and/or permanent pools of water in a highly engineered system require inspection monthly and after large storm events, in order to identify any problems with flow conveyance or vegetative health before they become serious. All other BMPs should be inspected quarterly and after large storm events. Following that initial period, assuming facilities continue to operate without problems and depending upon the type of facility, inspections may be conducted annually or, at the absolute minimum, once every five years.

A greater number of inspections may be required if the BMP is poorly designed or due to other factors, such as upstream development, that may cause operational or maintenance problems. Inspection records should be available upon request. An qualified professional should conduct BMP inspections.

A community should use standard inspection checklists to record the condition of all stormwater BMPs. Using consistent forms makes it easier for communities to track maintenance activities electronically, using either a database or spreadsheet, rather than relying on paper files (discussed further below). Well-designed checklists can be integrated within maintenance databases to prioritize maintenance, track performance over time, and relate design characteristics to particular problems. **Appendix 9-C** at the end of this chapter provides templates for maintenance checklists based on each type of BMP. Program managers can use these templates to customize their own maintenance checklists.

Table 9.7. Recommended Inspection Frequency for BMPs

Inspection Frequency	BMPs
Monthly and within 24 hours after every water quality storm (greater than 1-inch of rainfall)	Constructed Stormwater Wetlands Wet Ponds Wet Extended Detention Basins Bioretention Cells
Quarterly and within 24 hours after every water quality storm (greater than 1-inch of rainfall)	Level Spreaders Infiltration Devices Filter Practices Dry Extended Detention Basins Permeable Pavement Rain Tanks and Cisterns Vegetated Roofs Filter Strips* Wet and Dry Swales* Grass Channels* Restored Riparian Buffers*
*Although these devices require quarterly inspection, mowing will usually be done at more frequent intervals during the growing season.	

Source: NCDENR, 2007

Program managers may incorrectly assume that nonstructural BMPs, such as vegetated measures, do not require routine inspection and maintenance. In fact, proper maintenance of non-structural BMPs is essential for continued performance. Like structural BMPs, restored natural and riparian areas, disconnected impervious surfaces, grass channels, and similar practices can fail if inspections and monitoring are not routinely conducted.

For example, sediment build-up and debris at BMP inflow points may prevent sheet flow from reaching pervious areas or buffers. Vegetation used to restore natural areas may not have adequate survival rates. Landowner practices and behaviors, such as dumping yard waste and re-routing roof drains, may compromise the function of a nonstructural BMP. For all these reasons, inspection and maintenance procedures should be applied to LID and non-structural practices.

Inspectors should take photographs of all BMPs. In addition, specific critical features or potential problem areas should be photo-documented. For example, a recommended list of photographs for a BMP pond would include the following:

- Vehicle access points
- Overview of areas or related structures surrounding the pond
- Pre-treatment areas
- Wetland planting areas, if applicable
- Inlets

- Overview of principal spillway, upstream and downstream faces of embankments, and the emergency spillway
- Downstream outfall(s) from the BMP
- Before and after photos of any problem areas that must be repaired

9.3.8. Train Inspectors

Training workshops can help standardize the inspection process by reviewing objectives, procedures, and follow-up actions. In addition, peer-to-peer training enhances communication because inspectors can share challenges and problem-solving related to real field experiences. Training tied to inspector certification can also be a motivator to encourage others to participate. To support this scenario, the state or the local program could sponsor inspector training events and maintain lists of locally trained inspectors to promote consistency and quality control. The DEQ will provide Stormwater Management Inspector Training and Certification for local inspectors to become familiar with the unique aspects of SWM BMPs.

Inspector training is essential for a local program that conducts most of its own maintenance operations. Inspectors need to be well versed in the use of the checklists and need to provide feedback to program managers regarding maintenance activities (**Figure 9.4**).

Figure 9.4. Inspector training helps inspectors understand the function and maintenance needs of BMPs (Source: CWP, 2008)

9.3.9. Establish a Tracking System

Regardless of whether the municipality or the property owner is performing the BMP maintenance, tracking maintenance activities is important. Again, accurate tracking of inspection and maintenance activities will enable the local program to generate accurate reports, as needed to meet MS4 permit conditions and Virginia stormwater management regulatory requirements. In order to accurately track BMP maintenance activities, local programs must inventory BMPs, including collecting information on the physical condition of the structures and determining whether the BMPs are within easements (or under fee-simple ownership) and have adequate maintenance access. **Table 9.8** lists typical items that should be included in a BMP inventory.

Table 9.8. BMP Inventory Checklist

Physical Condition	Programmatic Condition
• Type of BMP • BMP Design Features: size of practice, drainage area, treatment area/volume, design storm(s), pipe sizes, etc. • Structural stability of dams/impoundments, if applicable • Integrity of pipes and risers • Condition of emergency spillway or bypass channel • Manholes and inlets in place and locked (if necessary) • Standing water or nuisance conditions • Erosion, sedimentation or sediment build-up • Evidence of sinkhole formation or subsidence within the BMP's footprint or drainage pathways • Evidence of clogging, ponding (infiltration, bioretention, filters, etc.) • Evidence of dumping (trash, yard debris, etc.) • Status of vegetation • Water enters and exits BMP as designed • BMP is built according to design (e.g., dimensions, size, elevations, geometry, etc.)	• Is the BMP within the easement? Are easement dimensions adequate? Any utility easements (that may interfere with BMP function or maintenance)? • Any existing maintenance agreements in force? • Maintenance access is platted and exists in good condition on the ground?

Source: CWP 2008

In large communities, tracking systems are technically advanced and use linked systems comprising geographic information systems (GIS – see **Figure 9.5**), global positioning systems (GPS), hand-held data collectors and related computer databases to track location, ownership, condition, and other BMP characteristics. Automated systems can be established to send notices to property owners when inspections and routine maintenance should be performed, or when an inspection by a municipal staff person reveals specific maintenance needs. However, simpler GIS and hard-copy file formats can also be used. **Table 9.9** lists items that are appropriate for local programs to track.

After changes in property ownership, updating responsible party information is an important, but often difficult, tracking function. Often, no formal mechanisms are in place for notifying local programs when a property with a deeded maintenance agreement is sold. The local program must work with the real estate office or send frequent (annual) notices to responsible parties requesting updated information.

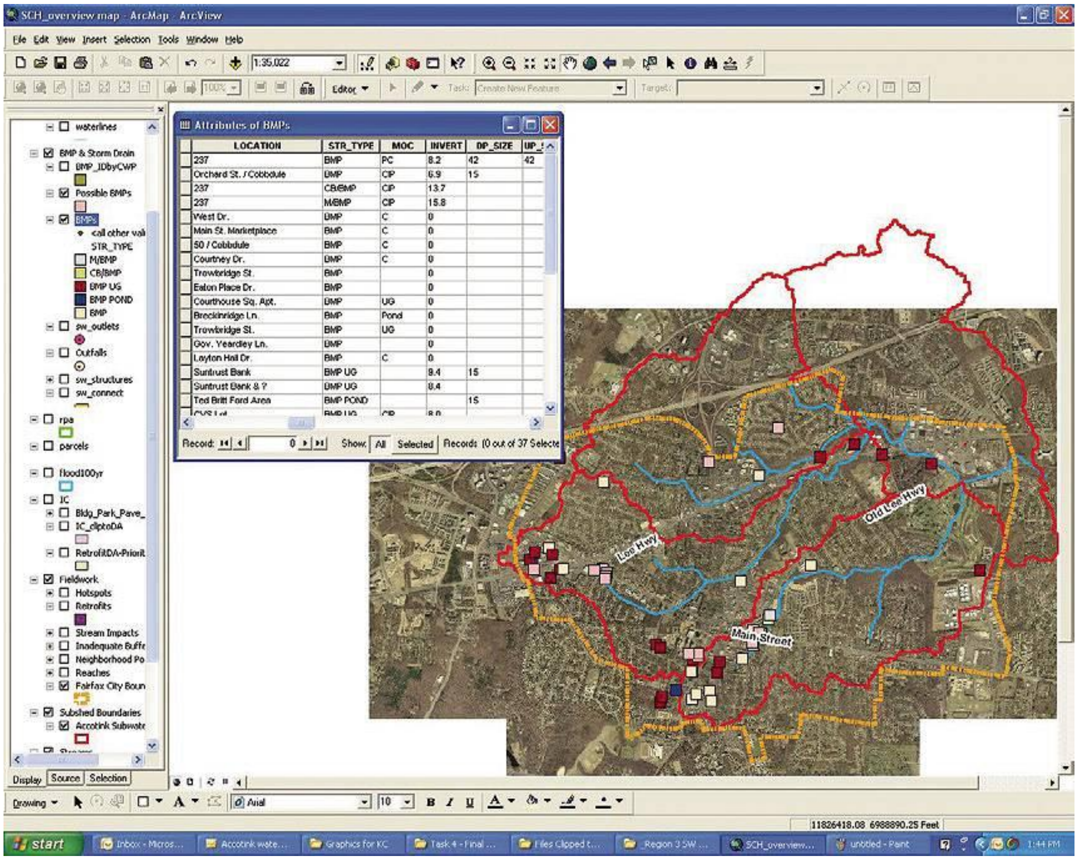


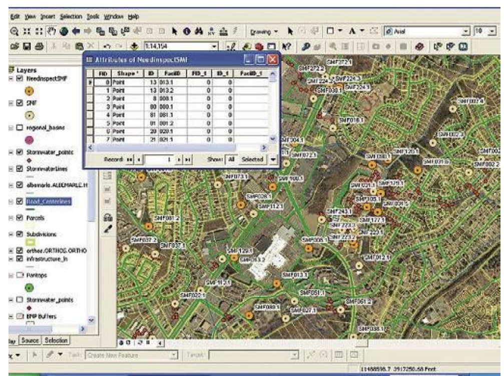
Figure 9.5. Example BMP Computer Tracking System
(Source: CWP 2006; Graphic: Albermarle County, VA)

Another critical task is collecting data about specific maintenance activities and their costs. Tracking systems can monitor costs for performing inspection and maintenance services. These data can assist local programs in estimating future expenses and developing more cost-effective means to accomplish tasks.

Benchmarks must be established for tracking and monitoring BMPs. For example, in ponds and wetlands, sediment markers (graded measuring sticks) placed in forebays or permanent pools can be used to consistently measure the depth of sediment during inspections. Similar markers can be used to ensure that the elevation of the permanent pool remains relatively constant over time. Sediment clean-out markers should also be used in underground vaults and in the sediment chambers of sand filters.

Table 9.9. Tracking Items for a Municipally Operated Maintenance Program

- Inspection dates and reports
- BMP locations
- General condition of BMPs
- BMP features: size of practice, drainage area, treatment volume/design storm, age, pipe sizes, etc.
- Photos
- Information needed to prioritize maintenance tasks. For instance, the inspection process can categorize BMP maintenance needs as (1) no action, (2) routine maintenance needed, (3) major maintenance needed, or (4) remediation/reconstruction needed. This type of BMP triage system is necessary to allocate available resources.
- Maintenance work orders
- Maintenance schedules and/or documentation on tasks completed
- Costs for various maintenance tasks
- Available BMP feedback or evaluation data that can help program managers amend the list of approved BMPs or particular BMP design features
- Good retrofit opportunities



Source: CWP 2008

9.3.10. Obtain As-Built Plans

After construction is completed, qualified engineers and surveyors should prepare as-built drawings of BMPs for a permanent record of the structures. The as-built plans are a critical element of future inspections. Although the acceptance of as-built plans is primarily a plan reviewer function, construction inspectors can play a key role in confirming the accuracy of as-built plans. They can also add documentation to the file that might be extremely useful for the maintenance inspection staff, who will ultimately inherit inspection responsibilities.

As-built plans should be prepared by qualified engineers and surveyors to verify that post-construction BMPs have been installed according to plans and specifications. Inspection staff should confirm these as-built plans and take photographs of as-built conditions. Doing so will provide useful documentation and help answer questions when future maintenance issues are identified (**Figure 9.6**). This is particularly important for control practices that may change their function during transition from the construction process to the post-construction setting. Examples are sediment basins that become permanent ponds, or sediment traps that are converted to biofilters.

In some programs, the staff that inspects post-construction BMPs during the construction process is the same staff that inspects them afterwards for maintenance purposes. In other cases, different staff members, facility owners, or responsible private parties actually perform maintenance inspections.

A special case might exist when proprietary BMPs are installed. When transferring these projects to the maintenance program, some stormwater managers require additional documentation, beyond as-built plans, to help ensure long-term maintenance. At this stage, the local program can require verification of maintenance contracts or a limited-duration (e.g., 3 years) maintenance bond to ensure that maintenance of these devices is actually initiated (especially if the designs are maintenance-intensive).

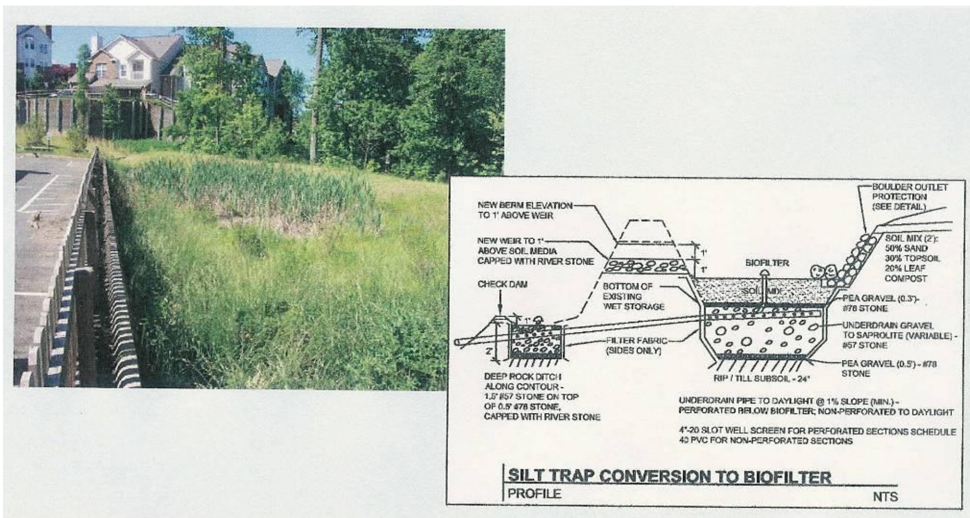


Figure 9.6. Construction inspectors should be involved in confirming as-built plans (Source: CWP 2008)

It is important to note here that the Virginia SWM Regulations do not, at this time, require the submission of as-built plans. However, as noted above, as-built plans are critical for effective long-term BMP maintenance. The SWM Law authorizes local governments to enact provisions of their local programs that are more stringent than those specified in the state regulations. Localities should consider using this authorization to require submission of as-built plans.

9.3.11. Perform and Document Maintenance Activities

Because of the overhead equipment costs and specialized skills needed to conduct the full range of maintenance activities, it is common for all but the largest communities to rely, at least partially, on outside contractors to conduct maintenance and repair activities (**Figure 9.7**). As noted above, one alternative is to form a separate organization, or special "district" (e.g., a Stormwater Utility) that is responsible for all maintenance and inspections. Another option is to assign stormwater maintenance responsibilities to an existing utility, such as a water and sewer authority. Such a utility or district would have a dedicated funding source to ensure longevity.

Inspectors should clearly document items that require repairs. Notations on design plans and physical markers, such as spray painting the key areas of concern, can help maintenance crews locate and correct problems. In addition, the inspector should mark potential corrections and problem areas on a copy of the as-built plan. The marked-up as-built plan should be stored digitally or in a paper file system, for reference. As noted above, photographs should be taken and kept in the record. Such records can be used on the follow-up inspection and will help confirm that maintenance was performed correctly.

Figure 9.7. Municipal staff, contractors, or both can perform maintenance tasks (Source: CWP, 2008)

Neglected repairs, or missing or damaged structures, may pose immediate safety concerns. Examples include a missing manhole cover over a drop inlet, a damaged grate at a large inflow or outfall pipe, or damaged fencing around a pond with steep slopes, which may allow unauthorized and unsafe access. Furthermore, repairs related to dam safety and flooding hazards must be implemented immediately. For example, if a BMP shows signs of embankment failure, or if an inspector is unsure, a qualified engineer should investigate the situation immediately and appropriate corrective actions must be taken. Similarly, cracks in a concrete riser for a pond that drains a large area may pose a safety threat and should be repaired immediately.

9.3.12. Administer Compliance and Enforcement Procedures

The local program is responsible for enforcement actions when maintenance activities are not conducted (see 4 VAC 50-60-116). Language in ordinances should specifically define maintenance enforcement procedures and time lines. Typically, municipalities are responsible for educating property owners about these procedures.

A tiered enforcement procedure is often best. Initially, responsible parties can be notified, either verbally or in writing (essentially given a "warning"), of inspection and maintenance tasks. If needed repairs are not performed accordingly, a more formal notice of violation, which outlines specific tasks and a completion schedule, can be issued. In cases of continued noncompliance or negligence, or where lack of maintenance poses a threat to public health and safety (e.g., a potential dam breach), fines or other penalties may be assessed and issued. **Table 9.10** below summarizes several compliance and enforcement methods that can be used for BMP maintenance.

Table 9.10. Review of Available Compliance Methods

Method	Stage of Compliance	Description
Maintenance Agreement	Recorded at the project review. Used during the life of the BMP as the basis for other enforcement measures.	This agreement is a contract between a local government and a property owner and is designed to guarantee that specific maintenance functions are performed. A maintenance agreement usually specifies that, in cases of noncompliance, the local program is legally authorized to enter the property to make necessary repairs and then assign applicable costs to the owner. Examples of maintenance agreements can be found in **Appendix 9-B** of this chapter.
Performance Bond	Posted at the project review, usually to ensure the proper construction of BMPs and installation of other SWM systems. The bond period can be extended to cover the initial period (e.g., 2 years) of maintenance after construction.	In a typical stormwater management performance bond, a site developer or property owner guarantees that construction of stormwater BMPs will be completed in accordance with the terms of the stormwater ordinance and approved stormwater design plan. Should the site developer or property owner fail to meet the performance measures, the bond ensures that enforcement action and corrective actions can be taken by the jurisdiction at the developer's or property owner's expense.
Notice of Violation (NOV)	This is the first stage of enforcement, following inspection and documentation of non-compliance	As a first step in the compliance process, the owner or responsible party is sent a NOV outlining the nature of the violation, the specific actions needed to come into compliance, a schedule for completing the remedies, and subsequent penalties that can be imposed if the actions are not taken.
Civil Penalty	An escalating level of enforcement if the NOV does not lead to compliance and the bond has already been released	As an incentive for compliance, a municipality is authorized to levy a monetary penalty for noncompliance. This penalty can be a fixed amount, or the amount could increase with the severity of the violation, frequency of occurrence, or length of time passing prior to achieving compliance status.
Criminal Penalty	An alternative to a civil penalty when the remedies listed above are not sufficient	A criminal penalty can be levied for more serious cases in which a party can be considered intentionally or knowingly negligent. Section 10.1-603.14 of the Act establishes the basis for both misdemeanor and felony charges for violations of the Stormwater Management Act and Regulations.
Maintenance Escrow Requirement	This is not common, but it could be an effective tool at the completion of construction	A property owner is required to post a performance bond, cash escrow, letter of credit, or other acceptable form of performance security in an amount that would cover the costs associated with maintenance and repair or replacement in the event of BMP failure (see § 62.1-44.15:34, Code of Virginia).

Source: Adapted from CWP 2008

9.3.13. Periodically Review Regulations and Procedures

Once a community's stormwater management operation and maintenance program has been developed and implemented, it may become apparent that changes or modifications are necessary to make the program more effective. Review of the operation and maintenance program should be scheduled one to two years after implementation. After the initial review, additional reviews may be scheduled in three to five-year intervals. Reviews should include input from staff members who are performing the various activities.

The following are some examples of issues that may arise during the review:

- The system inventory may not be complete or up-to-date.
- Inspection scheduling may need to be revised for more or less frequent inspections for all or only specific types of systems.
- Inspection checklists may need modification.
- Maintenance activities may need to be modified.
- Some systems or system components allowed may need to be deleted based upon experiences.
- Some systems or system components may need to be added based on new techniques or developments.
- Additional equipment may be necessary to perform duties adequately.

9.4. PUBLIC INVOLVEMENT IN THE MAINTENANCE PROGRAM

Educational outreach programs can improve compliance with maintenance requirements. Local governments should consider providing residential or commercial property managers with BMP inspection training and workshops on how to perform basic maintenance. **Table 9.6** above provides a list of typical stakeholders and strategies for involving them in a maintenance program.

A telephone hotline, or a web site with a reporting form, is a good tool for increasing citizen involvement. Using these methods, citizens can notify local program staff about specific maintenance issues or observed violations, request an inspection, or ask technical questions. In response, local programs would have to establish a procedure for addressing these reports or queries quickly. The hotline or web site should be advertised in utility inserts, the government pages of the local telephone phone book, on the municipal web site, and through other communication channels.

9.5. SUMMARY OF BMP OPERATION AND MAINTENANCE TASKS AND ACTIVITIES

9.5.1. Emergency Maintenance

Maintenance after floods and other emergencies requires immediate mobilization. The response can include replanting vegetation and repairing damaged structures. Living systems are likely to need at least minor repairs after emergencies. Following an emergency such as a flood, standing water may pose health risks because of mosquitoes or contact pollutants. Mosquito control and blocking access should be considered if this becomes a problem.

Obstructions and debris deposited during storm events should be removed immediately from all installations. Exceptions include debris that provides habitat and does not damage vegetation nor divert currents to, from, or within the BMP. In fact, because of the high quality habitat that can be found in woody debris, careful repositioning rather than complete removal may be desirable. There may be instances where debris is even added. Such locations should be noted so that the debris is not accidentally removed. Educating adjacent property owners about the habitat benefits of certain kinds of debris and vegetation can decrease requests for removal.

Formation of sinkholes or other evidence of subsidence within an BMP footprint or its drainage pathways indicates failure of the BMP. The practice should be repaired as soon as feasible after the first observation, using appropriate angineering techniques (e.g., VDOT IIM228 – *Sinkholes: Guidelines for the Discharge of Stormwater at Sinkholes; WVDEP, 2004; MDE, 2000; etc.*).

Figure 9.8. BMP Sinkhole Collapse

9.5.2. Routine Debris and Litter Removal

Trash removal is an integral part of BMP maintenance. Generally, a "spring cleanup" is needed to remove trash from all surface BMPs. Subsequently, trash removal is performed as required, based on observations during regular inspections. Special attention should be given to removing floating debris, which can clog the outlet device or riser. Regularly removing debris and litter is well worth the effort and can be expected to help in the following ways:

- Reduces the chance of clogging in outlet structures, trash racks, and other facility components.
- Prevents damage to vegetated areas.
- Reduces mosquito breeding habitats.
- Maintains facility aesthetics.
- Reduces conditions for excessive surface algae.
- Reduces the likelihood of stagnant pool formation.

9.5.3. Stability and Erosion Control

The best way to promote soil stability and erosion control is to maintain a healthy ground cover in and around the BMPs. Areas of bare soil quickly erode, potentially clogging the facility with sediment and threatening its integrity. Therefore, bare areas must be stabilized as quickly as possible. Newly seeded areas should be protected with mulch and/or an erosion control mat that is securely staked. For BMPs that rely on filtration, such as bioretention facilities, it is critical that adjacent soils do not contaminate the selected filter media during or after construction. If the site is not permanently stabilized with vegetation when the filter media is installed, the best design practice is to specify sod or other robust erosion control practices for all slopes in and immediately around the BMP.

Erosion is quite common in or around the inlets and outlets of BMP facilities and should be repaired as soon as possible. Erosion control efforts should also extend to areas immediately downstream of the BMP.

The roots of woody vegetation (e.g., young trees and shrubs) can cause embankments to be unstable. Consistent mowing of the embankment controls stray seedlings that take root. Growth of trees and shrubs further away from the embankment should not pose a threat to the stability of the embankment and can provide important runoff filtering benefits. Trees and shrubs should *not* be planted within maintenance and access areas.

Animal burrows also diminish the structural integrity of an embankment. Muskrats, in particular, burrow tunnels up to 6 inches in diameter. Efforts should be made to control animal burrowing. Burrows should be filled as soon as possible.

Finally, subsidence can result in sinkholes on embankments or basin and channel bottoms. Subsidence is not soley related to karst areas. *The presence of subsidence or sinkholes anywhere within the BMP perimeter or along the treatment train can short-circuit the stormwater management system, and it should always be considered a criterion of BMP failure that must be addressed and corrected.*

9.5.4. Sediment Removal and Disposal

Sediment gradually accumulates in BMPs and must eventually be removed. However, removal intervals vary so dramatically among facilities that no “rules of thumb” are applicable. The required frequency of sediment removal is dependent on many factors, including the following:

- The type of BMP;
- The design storage volume (e.g., if the active and permanent pool storage is oversized for sediment storage);
- The characteristics of the upstream catchment area (e.g., land use; level of imperviousness; upstream construction activities and effectiveness of sediment and erosion control activities); and
- Municipal practices (e.g., winter weather roadway sanding and salting, etc.) in the contributing drainage area.

Before installing a BMP, the designer should estimate the lifetime sediment accumulation that the BMP will have to accommodate. Several time periods may be considered, representing expected changes in land use in the watershed. To estimate sediment accumulation, an estimate of the long term sediment load from upstream must be calculated (see an example method in **Appendix 9-E** at the end of this chapter). Then an estimate of the BMP's sediment removal efficiency must be determined. The analysis of watershed sediment loss and BMP efficiency can be expedited by using a sediment delivery computer model.

The frequency of sediment removal is then based on the sediment accumulation rate versus the amount of sediment storage volume that is inherently provided in the BMP without affecting treatment efficiency or stormwater storage volume. Again, the frequency of sediment removal is BMP- and site-specific. It could be as often as every 2 years, or as long as 15-25 years. The volume of sediment that must be removed and disposed of each dredging cycle is the volume calculated above multiplied by any density or dewatering factors, as appropriate.

Wet sediment is more difficult and expensive to remove than dry sediment. Ideally, the entire facility can be drained and allowed to dry sufficiently so that heavy equipment can operate on the bottom. Provisions for draining permanent pools should be incorporated in the design of water impoundments, where feasible. Also, low-flow channels and outlets should be included in all BMPs in order to bypass stormwater flow during maintenance. However, in many impoundments periodic rainfall keeps the sediment soft, preventing access by heavy equipment. In these cases, sediment may have to be removed from the shoreline by using backhoes, grade-alls, or similar equipment.

Underground or proprietary BMPs – such as vaults, chambers, and other structures that require accumulated material to be pumped out – require special consideration. For such facilities, inspection and maintenance staff may be required to have confined-space training to satisfy OSHA safety requirements. Also, some types of proprietary devices require more frequent maintenance in order to perform as designed. Maintenance contracts are essential when such BMPs are specified on plans.

At sites where sediment loads are expected to be high, designers should designate a dewatering and storage area on the site. This area must be located outside of the floodplain. If such a disposal area is not set aside, transportation and landfill tipping fees can greatly increase the cost of the BMP's maintenance, especially if disposal of wet sediment is not allowed in the local landfill. If on-site storage is not feasible, sediment can be used elsewhere after dewatering, unless the material was generated from a stormwater hot spot (e.g., a gasoline station). In this case, a Toxicity Characteristic Leachate Procedure (TCLP) or other analysis should be performed on the removed sediment to determine if it meets the criteria of a hazardous waste, which requires special handling and disposal. If the waste is not a hazardous waste and is going to be managed as a solid waste, other testing may be required by a receiving facility.

Sediment removed from a BMP requires proper disposal, which must be carefully planned. Some pump-outs result in a waste material that is composed of both liquids and solids. Wastewater plants usually do not accept wastewater with solids, and sanitary landfills usually do not accept any liquids or saturated sediments. Therefore, sediment removal activities must result in a waste material that meets the various disposal requirements. State waste disposal requirements should be consulted for information pertaining to the exact parameters and acceptable levels for different disposal options. Generally, sediment removed from BMPs will not be contaminated to the point that it would be classified as hazardous waste. However, all sediment removed from BMPs should be tested to determine the proper disposal option. Most private laboratories are familiar with waste disposal regulations and can test sediment samples with these in mind. Generally, there are three sediment disposal options:

- **On-Site Disposal.** On-site disposal allows the sediment to be disposed of on any land area that is not regulated (i.e., land other than floodplain, etc.). During the site planning process, when determining land requirements for stormwater control measures, land can be set aside for on-site disposal of sediment removed from the various BMPs during maintenance. The areas that are used for sediment disposal should be landscaped after each sediment removal operation, inorder to stabilize the soil and provide a natural appearance.

- **Off-Site Disposal.** Off-site disposal is often preferred by developers and municipalities. Off-site disposal does not reduce the developable area, landscaping/grading does not have to be performed, and there are no perceived liability/health concerns with respect to the surrounding landowners. Off-site disposal can mean disposal at a sanitary landfill or disposal at another area undergoing filling. The decision of where the material is deposited depends on the quality of the sediments and the availability of and distance to the alternative fill areas.

  Temporary disposal areas are recommended for surface end-of-pipe stormwater management facilities – particularly those that do not have a maintenance by-pass – since this provides a location for the sediment to dry before transporting it off-site. Where temporary sediment disposal areas (i.e., drying areas) are not feasible due to limited availability of land or high cost, the means of dealing with the un-dewatered sediment should be detailed in the SWM plan and and maintenance agreement, which must be approved by the municipality.

- **Hazardous Waste Disposal.** Although sediment removed from BMPs is expected to contain contaminants (metals, bacteria, nutrients), the levels of pollutants involved are typically not sufficient for it to be classified as hazardous waste. Hazardous waste must be deposited at a hazardous waste facility. Transportation costs and disposal fees are expensive for hazardous waste, since licensed haulers must be used to transport the material and the number of accessible hazardous waste receiving facilities may be limited in number or distance.

9.5.5. Maintenance of Mechanical Components

Each type of BMP may have mechanical components that need periodic attention. For example, valves, sluice gates, fence gates, locks, and access hatches must be functional at all times. The routine inspection, exercising, and preventive maintenance for such mechanical components should be included on a routine inspection/maintenance checklist.

9.5.6. Vegetation Maintenance

Vegetation maintenance is an important component of any stormwater maintenance program. The grasses and plants in all BMPs require regular attention, but particularly in vegetative BMPs such as filter strips, dry and wet swales, grass channels, restored riparian buffers, bioretention facilities, and constructed stormwater wetlands. The development of distressed vegetation, bare spots, and rills indicates that a BMP is not functioning properly. Problems can have many sources, such as the following:

- Excessive sediment accumulation, which can clog the soil pores and produces anaerobic conditions.
- Nutrient deficiencies or imbalances, including pH and potassium.
- Water-logged conditions caused by reduced soil drainage or a high seasonal water table.
- Invasive weeds.

The soil in vegetated areas should be tested every other year and adjustments made to sustain vigorous plant growth with deep, well-developed root systems. Soil aeration is recommended for filter strips and grassed swales where sediment accumulation rates are high. Ideally, vegetative cover should be mown infrequently, providing for the development of thick stands of tall grass and other vegetation. Also, trampling of vegetation by pedestrian traffic should be prevented.

Areas immediately upstream and downstream of some BMP plantings often experience increased erosion. Although properly designed, located, and transitioned installations experience this effect to only a minor degree, all erosion should be repaired immediately to prevent spreading. Live stakes, live fascines, and other soil bioengineering techniques, possibly in combination with 3-D geotextiles, can be applied to erosion in natural drainage ways with minor grading.

Table 9.12 below describes some of the vegetation-specific maintenance activities at various types of BMPs. It is important to note that there are specific requirements related to certain management practices that *must* be followed, such as those performed within buffers. In addition, vegetation should be removed if it poses threats to human safety, buildings, fences, and other important structures. Finally, vegetation maintenance activities naturally change as the vegetation matures after construction.

9.5.6.1 Grass Cutting

Generally, grass-cutting should be limited or eliminated around SWM facilities. Allowing grass to grow tends to enhance water quality and provide other benefits for wet facilities. Short grass around a wet stormwater facility provides an ideal habitat for nuisance species such as geese. Allowing the grass to grow is an effective means of discouraging geese. Grass cutting is one maintenance activity that is undertaken solely to enhance the perceived aesthetics of the facility. The frequency of grass cutting depends on surrounding land uses, local municipal or HOA by-laws, and public or peer pressure. In view of the various influences, grass cutting should be done as infrequently as possible but with sensitivity to the aesthetic concerns of nearby residents.

Grass around wet facilities should not be cut to the edge of the permanent pool. As a safety precaution, cutting should be done parallel to the shoreline with grass clippings being ejected upland, in order to avoid adding organic matter to the pond.

Table 9.11. Vegetation Maintenance for BMPs

ACTIVITY	INSTRUCTIONS
Replacement of Dead Plants	All dead plants should be removed and disposed of. Before vegetation that has failed on a large scale is replaced, the cause of the failure should be investigated. If the cause can be determined, it should be eliminated before vegetation is replaced.
Fertilization	The objective of fertilizing at a BMP is to secure optimum vegetative growth, rather than yield (often the objective with other activities such as farming). Infertile soils should be amended before installation and then fertilized periodically thereafter. Fertilizer can be composed of minerals, organic matter (manure), compost, green crops, or other materials.
Irrigation/ Watering	Watering vegetation is usually necessary during the germination period, as well as occasionally thereafter to preserve the vegetation through drought conditions. This can typically be accomplished by pumping water the BMP pool or from the stream, installing a permanent irrigation system or frost-proof hose bib, or using portable water trucks.
Mulching	Mulch should be used to maintain soil temperature and moisture, as well as to improve site aesthetics. A 1/2-inch layer is typically adequate. Ideally, mulch should be removed before winter to prevent an infestation of rodents.
Weeding	Weeding is often necessary in the first growing season, particularly if herbaceous grasses are out-competing the young woody vegetation. The need for weeding may be largely eliminated by minimizing the amount of seed used for temporary erosion control. Weeding may also be required if, over time, invasive or undesirable species are entering the site and out-competing plants that are specifically desired for the treatment of the stormwater.
Cultivating/ Hoeing	Hoeing is often required to loosen overly-compacted soil and eliminate weeds that compete with the desirable vegetation.
Pruning	Pruning is used to trim plants to a desired shape and remove dead wood. Pruning can force single-shoot shrubs and trees to assume a bushier configuration.
Thinning	Thinning dense brush may be necessary for particular species to thrive, to increase the vigor of individual specimens, to reduce flow obstructions, and to increase the ability of maintenance staff to access the entire BMP. Tall maturing trees typically have no place in a BMP (except for buffers) and should be removed as soon as possible.
Staking	Saplings of tall trees planted in or near the BMP may require staking. Care should be taken not to damage the tree's roots or trunk with stakes or ties. Stakes should be kept in place for 6-18 months, and the condition of the stakes and ties should be checked periodically.
Wound Dressing	Broken or damaged branches and other wounds on trees should be dressed in accordance with recommendations from a trained arborist.
Disease Control	Based on monitoring observations, either insecticides or (preferably) organic means of pest and fungal control should be used.
Protection from Animals and Human Foot Traffic	Fencing and signage should be installed to deter pedestrians and to prevent damage due to trampling. These measures are often most necessary during the early phases of installation but may be required at any time. Measures for controlling human foot traffic include signs, fencing, floating log barriers, impenetrable vegetation, ditches, paths, and piled brush. Wildlife damage is caused by the animals browsing, grazing, and rubbing the plants. However, the use of chemical wildlife repellents should be avoided. Fences and meshes can be used to deter entry to the BMP. Tree tubes can be used to prevent damage to individual specimens.
Mowing	Mowing of perennial herbaceous grasses and wildflowers, especially once seed heads have set, promotes redistribution of seed for this self-sustaining system. However, mowing should be carefully controlled, especially when performed for aesthetics. As adjacent property owners and citizens in general learn more about BMPs, their vision of what is aesthetically pleasing can change. Grasses associated with BMPs, in healthy herbaceous stands, should never be mown more than once each year.

9.5.6.2 Weed Control

Weeds are generally defined as any kind of vegetation which is unwanted in a particular area. In terms of BMPs, weeds are generally invasive species which cannot provide the intended function of the planting strategy, or other non-native species such as purple loosestrife, the spread of which is undesirable. Local weed control rules should be consulted for local requirements. Weed control may be required annually.

Ideally, weeding should be done by hand to prevent the destruction of surrounding vegetation. The use of herbicides and insecticides, which cause water quality problems, should be prohibited near BMPs. The use of fertilizer should also be limited to minimize nutrient loadings to the downstream receiving waters.

9.5.7 Plantings

Upland and flood fringe plantings are generally stable and should not need much maintenance or re-establishment. Shoreline fringe areas are subject to harsher conditions as a result of the frequent wetting and drying associated with this zone. Aquatic plantings are the hardest to establish initially. Typically, vegetation in the aquatic and shoreline fringe zones will require some replanting or enhancement during the first two years of SWM facility operation. Preliminary results of studies of stormwater plantings indicate that a healthy vegetative community will establish if proper conditions are created (although the final set of species may not be those that were originally planted).

Planting methods can be separated into the following three main categories (from terrestrial to aquatic), based on the wetness level and types of vegetation that will grow in these conditions:

- **Upland/Flood Fringe.** The two types of plantings used are herbaceous (ground covers and grasses) and woody vegetation (shrubs and trees). Planting should occur in the spring after groundwater levels have normalized. Ground cover can be installed either by hydroseeding or using a custom seed mix in a nutrient rich medium impregnated in a biodegradable mesh-like blanket. Individual shrubs and trees can be planted manually, with openings made in the mesh blanket for each individual plant, if necessary.

- **Shoreline Fringe (Wet Riparian).** Shoreline fringe vegetation should be planted in mid-May to early June but after water levels have subsided to a stable level. Some form of protection of the seed mixture and soil nutrient medium (if required) should be provided in this dynamic zone of water level fluctuation. In order to establish ground cover in this zone, the biodegradable mesh-like blanket suggested for the upland zone is also highly recommended for this zone. Shrubs and trees can be planted through openings created in the mesh blanket.

- **Aquatic Fringe/Shallow Water.** The establishment of plantings in this zone will require greater material handling and growth monitoring, both in the short-term and over the long-term. Emergent vegetation is easily planted by hand if the substrate is suitable (e.g., ideally, a firm substrate with at least 10% organics by volume). Young shoots (rather than rhizomes or corms) are preferable for planting, since these plants are already growing with an established root structure (for early stability). The plants should be at least 10 cm tall, and planting should occur from late May to early June. Sprigs or plugs are preferable for planting emergent plants, since the root material is already contained in a suitable growth medium.

  Mature growth should be planted to establish submerged rooted plants (including pondweeds), if planted in late spring to early summer when the mature plants can take advantage of warmer water and sunlight penetration. Plantings in early spring or fall should use vegetative propagules such as turions or rhizome plugs, which can germinate in the spring or over the winter and begin growing in the following growing season.

9.5.8 Maintenance of the Aquatic Environment

An important yet often overlooked aspect of non-routine maintenance of BMPs that have a permanent pool of water is the need to regularly monitor and maintain conditions that promote a healthy aquatic environment. An indicator of excess nutrients (a common problem) is excessive algae growth in the permanent pool of water. In most cases, such problems can be addressed by encouraging the growth of more desirable aquatic and semi-aquatic vegetation in and around the permanent pool. The plants selected should be tolerant of varying water levels and have a high capacity to incorporate the specific nutrients associated with the problem. If algae proliferation is not addressed, algae-laden water will be washed downstream during rain events and may contribute to nuisance odors and pollution stresses in downstream aquatic habitat.

9.5.9 Insect Control

Ponded water can function as a breeding site for mosquitoes and other insects. Mosquito problems can be minimized through proper design and maintenance. The most effective control technique for prevention of mosquito breeding is to ensure that permanent impoundments do not develop stagnant areas. BMPs with permanent pools should include a source of steady dry-weather flow. Promptly removing floatable debris from the drainage path helps eliminate areas where water can collect and then stagnate. In larger basins, fish that feed on mosquito larvae can be stocked. Additionally, splash aerators can be employed to prevent stagnant water. However, aerators require electricity at the site, increases maintenance costs, and must be designed so as to not decrease the settling efficiency of the BMP.

9.5.10 Winter Operation

Infiltration facilities are subject to reductions in capacity due to freezing or saturation of the soil. Surface filters and bioretention areas are generally subject to similar problems. Subsurface filters, while less susceptible than surface filters, may demonstrate poorer performance in the winter due to freezing in underdrain pipes or the filter medium. Filters which use organic media are particularly prone to freezing because they retain water.

There is also an increased likelihood of infiltration facilities and filters clogging during winter operation due to the high sediment loads resulting from road maintenance activities (e.g., sanding and salting). Furthermore, there is an increased risk of groundwater contamination from road salt associated with winter operation of infiltration facilities that receive road runoff.

Where filters and infiltration systems are part of a treatment train, runoff that may be diverted in the winter to by-pass these BMPs but will still pass through some type of downstream controls.

9.5.11 Maintenance of Other Project Features

All other devices and features associated with BMPs should be monitored and maintained appropriately. These additional items could affect the safety or aesthetics of the facility, which can be as important as (if not more important than) the operational efficiency of the facility. Such items might include:

- Fences
- Access roads
- Trails
- Lighting
- Signage (e.g. no trespassing, emergency notification contact information, etc.)
- Nest boxes
- Platforms
- Watering systems

9.5.12 Monitoring

Stormwater monitoring is typically conducted at two levels:

- ***Watershed and Subwatershed Monitoring***. As noted previously, stormwater is best managed within the context of a watershed and subwatershed plan. These plans will normally contain a monitoring component to track implementation of the plan. The monitoring program will typically include administrative monitoring, water chemistry, biological monitoring, flow and erosion monitoring. These monitoring programs are essential to the success of the Plan. Subwatershed monitoring will normally be conducted or administered by the local conservation authority or municipality.

- ***Facility Monitoring***. The consensus of opinion among practitioners is that monitoring for chemistry or biotic parameters cannot be justified for each individual facility, because to have any scientific validity a large and costly sampling program is required. The approaches generally used are (1) physical operation monitoring by the owner or municipality to verify that the facility is operating as designed, and/or (2) detailed monitoring of a typical installation through a research program to evaluate design and performance issues. The designer is advised to consult with authorities regarding site-specific requirements, because some jurisdictions have additional monitoring requirements.

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